The Story of WATER

ONTARIO WATER RESOURCES COMMISSION

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CONTENTS

PART I — HISTORY, SUPPLY AND USE . . . . . . Page 1

PART II — THE ONTARIO STORY . . . . . . Page 5

PART III — WATER TREATMENT . . . . . . Page 6

PART IV — REMOVAL OF WASTES . . . . . . Page 10

PART 1 -- History, Supply and Use

The Concise Oxford Dictionary defines water as a colorless, transparent, odorless compound of oxygen and hydrogen in liquid state, convertible by heat into steam and by cold into ice.

To go beyond a mere definition of a word, it should also be stated that water is the most important of our natural resources because there can be no existence without it, or no progress where it is in short supply.

Water occurs naturally as a gas (vapor), a liquid, and a solid (ice), depending upon temperature and pressure. Under ordinary conditions it passes from solid to liquid at 32 degrees F.; from liquid to vapor at 212 degrees F.; and has its greatest density at 39.2 degrees F., in which state it is taken as the standard of density for solids.

In its solid form, ice, it is lighter than its liquid form. Because of this, it occupies more space per unit of weight. This characteristic causes pipes to burst, but it also conditions the soil.

Water comprises more than two-thirds of total body weight and about half the volume of the blood.

The solvent properties of water are unique among liquids. It is the ability of water to dissolve so many compounds as well as gases which gives rise to the many problems in its use. The dissolved compounds and gases of water vary from source to source and this is the reason for individual consideration of treatment required in the development of a water supply.

WATER and HISTORY....

Water dominates history. The early civilizations grew in the river valleys--the Nile, the Tigris and Euphrates, the Indus and the Ganges--of necessity, because people gathered where there was water, and where there was water there was food.

The ancient Chinese and Egyptians used chemical coagulants to purify their water--probably the first form of treatment, and the Romans built huge aqueducts to transport water to cities from outside sources.

In such times, only the very wealthy could afford to have water piped into their homes. Others were provided with public baths and fountains.

The beginning of the 17th Century brought with it pumps to lift water into reservoirs and into cities. The City of Paris around this time installed a pump to bring water from the River Seine. Britain's first municipal reservoirs were built in London in 1609.

Modern water treatment probably had its beginning with the development of the slow sand filter by James Simpson in England in 1829.

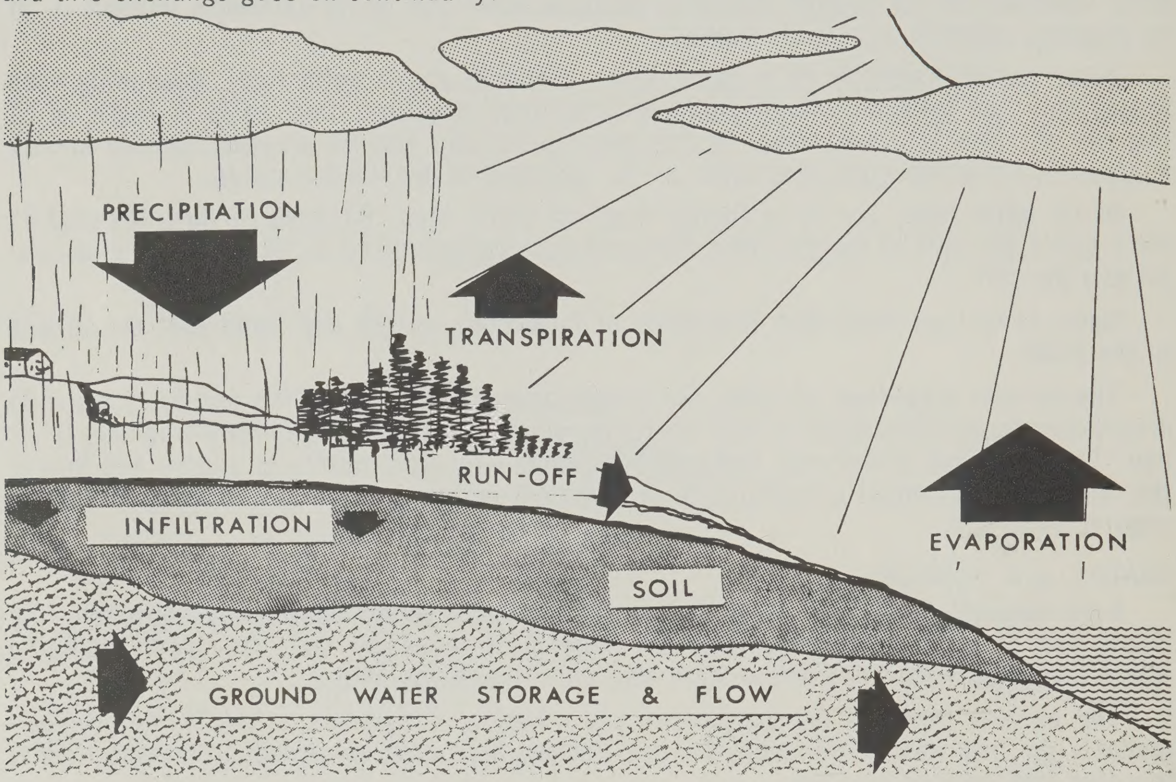
Later in the same century, scientists like Koch, Lister and Pasteur found that drinking water could bring death as well as life. Typhoid fever and cholera, two of mankind's most virulent diseases, were traced to water supplies. So were other diseases. Then, there gradually evolved the miracle of modern water purification processes--the curing of sick water--water made sick by pollution.

HYDROLOGIC CYCLE....

Water is a renewable resource--that is, its world quantity is constant. But, since it is continually on the move, problems occur when the water cycle gets out of balance and either too much or too little is available at any one place.

To explain in more detail the statement that "water is continually on the move", it should be realized that water is being exchanged between the earth and atmosphere all the

time. This exchange is accomplished by the heat of the sun and the pull of gravity. Water evaporates from wet ground, lakes, rivers and reservoirs, and through transpiration is drawn from leaves of growing plants, including trees. It is carried in the air as water vapor, a gas. When water vapor condenses it changes from a gas to a liquid and falls as rain. The rain feeds the rivers and lakes. Rivers carry water to the ocean. Evaporation from land-bound sources and the ocean, together with transpiration, puts water back in the atmosphere, and this exchange goes on continually.



The roots of plants take up water from the soil and push it up the stem to the leaves from where it is evaporated into the air. This is transpiration. It plays an important part in the hydrologic cycle as it brings up water from deep in the soil which might otherwise have remained longer on earth.

These plants use water in many ways--in producing food for growth, in cooling, and in respiration. Big trees may use up to 300 gallons of water per day but most of this water will be given back to the atmosphere in the process of transpiration.

It has been estimated that an acre of apple trees may lose, in transpiration, 600 tons of water in a season. On a hot day a good-sized apple tree may lose as much as a gallon of water a minute.

Moisture falling from the atmosphere in the form of rain, sleet, hail or snow is called precipitation. The amount of precipitation is measured in inches and is recorded daily in major centres for the purpose of statistics.

All precipitation becomes surface water or ground water. The visible part of the water cycle is the water which remains on the surface and is channelled to lakes, rivers and streams. Not all the water remains on top of the land, however. Some finds its way into the ground to become part of the earth's great reservoir of ground water.

Whether ground water is in plentiful supply depends upon many things and first and foremost are the conditions under the surface. If geological conditions are good for the under-

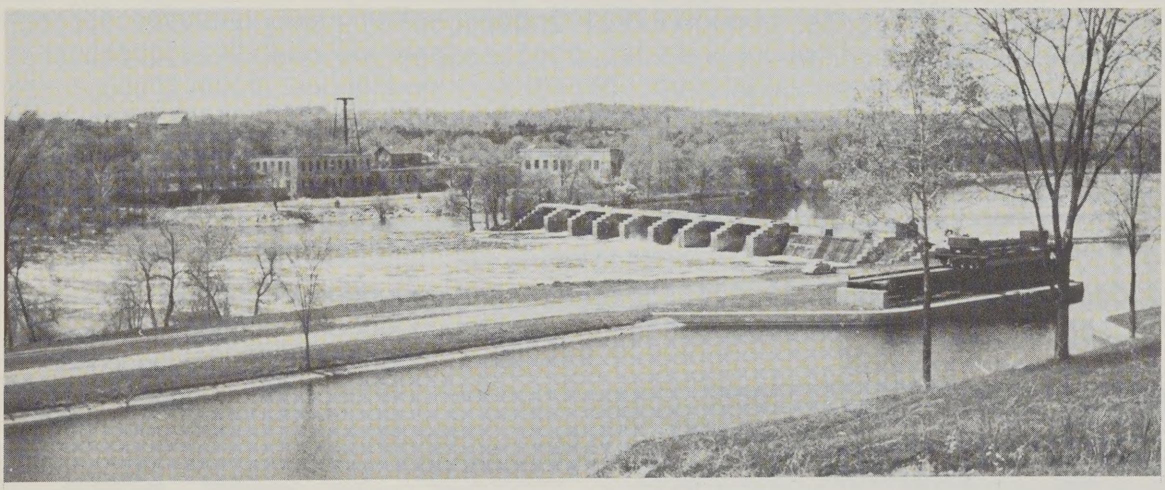
ground storage of water in any particular area, there should be a plentiful supply for normal uses. Unexpected heavy demands, however, can deplete ground water resources and lower the levels or tables.

For instance, increasing population and demands of new industry in any particular area, or a sudden imbalance in the normal rainfall, will have the effect of lowering those water tables.

Where surface waters are concerned, shortages have been caused by lack of proper conservation measures. Shifting and increasing population centres and pollution from human and industrial wastes also have contributed. And polluted water is no better than no water at all where essential and immediate human needs are concerned.

Man's environment is becoming more and more important and modern public health programs are aimed at making that environment suitable for both mental and physical health--both of the masses and the individual. So, once again, we can point to the importance of our water resources. All these factors, together with continually improving standards of living, only serve to point to water's importance and compel all of us to take a new look at water resources--and not before it is required.

The aims of any such new look should include development and conservation of both ground and surface water supplies and pollution control.



WATER USE....

Modern living has increased the use of water many fold. Gone are the days when water was used for drinking, washing, recreation and transport purposes only. The average family today uses as much in a day as many families once used in a week. The per capita consumption in Ontario is estimated to be 100 gallons each day, and this is rising. In some metropolitan areas, it tops 150 gallons a day. The industrial thirst for water--no problem in the 19th Century--has become fantastic and will increase. For instance, it takes 700 gallons of water in the processing of one barrel of crude oil--a ton of paper requires from 5,000 to 65,000 gallons--a ton of steel 9,000 to 19,000 gallons--250 to 450 gallons in the tanning of one hide.

Human requirements have been increased by present-day living standards in modern homes which include automatic washing machines, air conditioners and dishwashers.

It has been stated that water is a renewable resource. However, sometimes too much or too little is available at any one place, and polluted water is of no use for human consumption. Both problems usually can be corrected. They must be corrected if the expected future needs are to be met.

To meet shortages in any one area, water can be piped any distance from areas where there is an abundance of water. Ontario is particularly fortunate in that no heavily populated section is too far from one of the Great Lakes. In many sparsely populated districts, there generally is an abundance of ground water.

POLLUTION CORRECTION....

To meet the problems caused by pollution of water by human and industrial wastes, there are two courses of action, both of which can be, and must be, taken. Efforts have to be made to see that presently polluted watercourses are cleaned up. New pollution must be prevented by adequate treatment of all wastes before they are discharged into the watercourses.

Through adequate treatment of wastes and proper treatment of water required for domestic use, water can be used over and over again. It must be realized that practically all surface water requires some form of purification before it can be used domestically, whereas most ground water is available in usable form. Ground water usually is free from contamination by bacteria, but some sources do need treatment for removal of iron or hydrogen sulphide, or require the addition of a softener.

There are forms of treatment available for all strengths of domestic sewage contamination and for most types of industrial pollution, and this makes it possible in many instances to treat both wastes together in municipal treatment works. Many industries are self-sufficient enough to treat their own wastes. However, there are some types of industrial wastes which present persistent problems. The continual development of new products also compounds this problem in that little or nothing is known concerning their wastes.

This, naturally, constitutes a challenge to the research facilities of the industries concerned and, in Ontario, to the Ontario Water Resources Commission. The OWRC, through its Division of Research and the Division of Industrial Wastes co-operates with these industries in efforts to solve stubborn waste disposal and treatment problems.

The story of the Commission and its work is related in the next section of this publication.

PART 2 -- The Ontario Story

In Ontario, the Provincial Department of Health worked diligently in the related fields of water supply and treatment of wastes for many years. However, depression years of the 30s and the following years of war were stagnant in regard to progress in the fields of domestic water supply and waste water treatment. Then came boom years with expanding population and increased industrial effort. All this created problems which called for special action.

To meet these problems the Ontario Government in 1956 created, by Act of Legislature, the Ontario Water Resources Commission, subsequently making the agency responsible for the development, utilization and management of water resources and the provision of adequate pollution control measures in Ontario. The Commission divisions of Construction and Plant Operations construct and operate water works and sewage works through agreements with municipalities, after such projects have been organized and set up by the Division of Project Development. The divisions of Laboratories, Research, Sanitary Engineering and Water Resources are charged with the responsibilities of a variety of water resources and water management programs. The Division of Industrial Wastes checks industry in the disposal of its polluting wastes and assists industry in helping solve difficult disposal problems. It co-operates closely with the OWRC research experts in this work.

In water and sewage construction projects, the Commission has several procedures. It can enter into direct agreements with municipalities on an individual or area basis to arrange, on their behalf, financing, construction and operation of works on terms satisfactory to the municipalities involved. In such cases, the municipalities can take an active part in the operation of these projects through the appointment of local advisory committees. Commission supervisory personnel consult regularly with project staff and these local officials.

Another method is for the Commission to make use of Provincial Government funds to build such works for the use of municipalities, individually or in groups. Charges are related to actual use of the services provided.

Other items in the OWRC program include:

* Operation of survey programs on an individual stream basis or on county-wide or district bases to check on water quality, pollution control, and overall water resources.

* Control through a permit system of water use from all sources.

* A continual search for new ground water sources, and the licensing of the province's well drillers.

* Co-operation with industry in seeking solutions to persistent and new waste treatment problems.

* Control through a permit system of the use of chemicals to check the growth of algae and other aquatic nuisances.

* The review of plans for all water supply and pollution control projects to be undertaken by municipalities or persons. Such works cannot be undertaken without issuance of an OWRC Certificate of Approval.

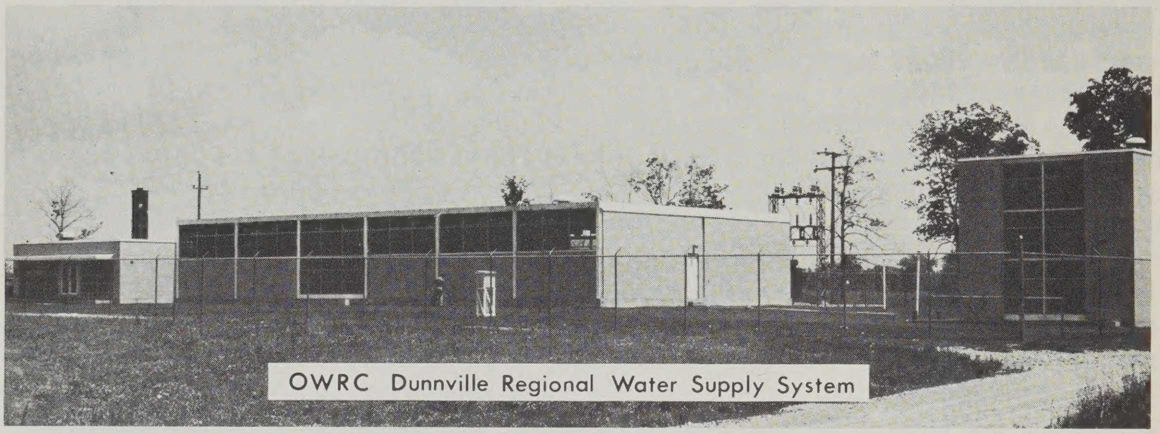
* Supervision of the operation of all water supply and water pollution control plants in the province.

PART 3 -- Water Treatment

Practically all large municipalities use surface water to obtain an adequate supply, whereas smaller communities, farms and some industries, use ground-water sources.

Requirements of a public water supply demand that it be free of disease-bearing organisms, free of odor, clear and colorless, reasonably soft, free from objectionable gas and minerals, and be plentiful and low in cost. This is a large undertaking in view of the amount of waste materials discharged into watercourses.

There are a number of methods widely used to achieve water purification, and also a number of special processes and modifications. In many cases it is necessary to use a combination of processes to achieve the results desired.



OWRC Dunnville Regional Water Supply System

The treatment processes and equipment outlined here may all be utilized in any one plant or only a few may be required. The degree and type of treatment necessary, in any specific area, is determined by the water quality at the source.

Almost all surface-water supplies are turbid, colored or contain bacteria or algae. Turbidity is the term applied to the finely-divided suspended and colloidal material in water which is too light to settle readily. Color in water is caused by dissolved organic matter, including decaying vegetation. Bacteria and foreign matter must be removed to protect the public health. Therefore, the object of treatment is to utilize the most effective processes and equipment for the removal of impurities present in a specific source.

LOW LIFT STATION....

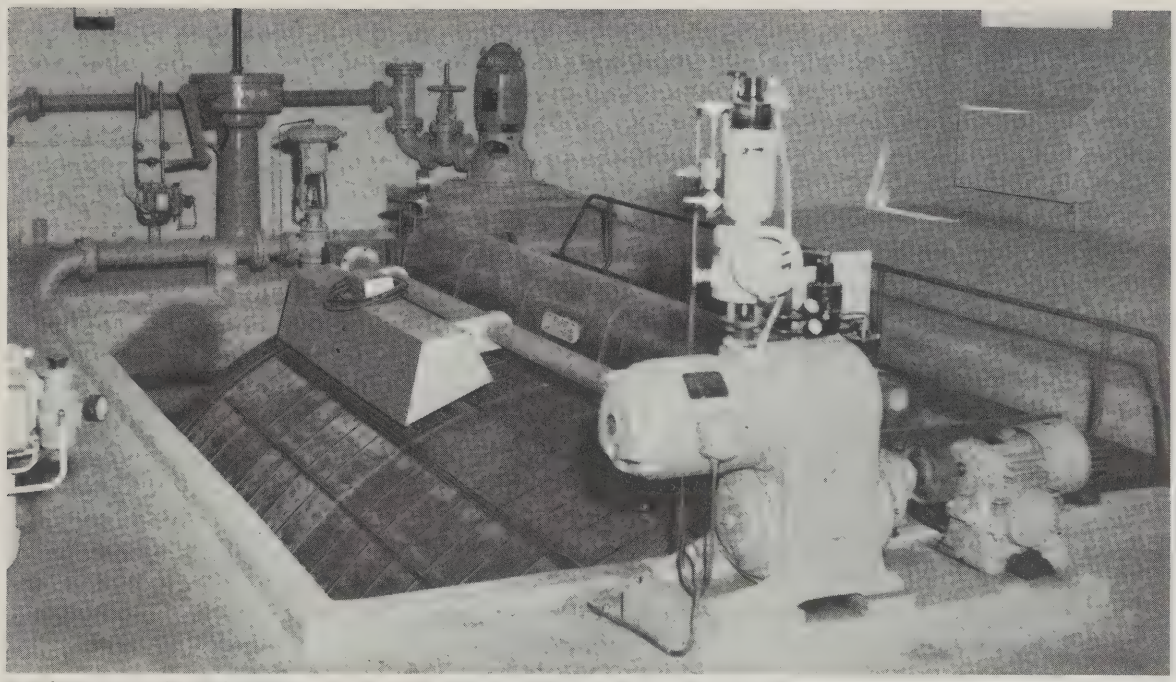
A low lift station is a raw water receiving station and reservoir, which is equipped with pumps, motors, screens and other equipment. An intake pipe extends out from this station into the lake or river and the water enters the raw water reservoir by gravity.

Located in the building, at the terminal point of the intake, is a bar screen, which obstructs the passage of any large objects entering the intake. Following this are usually stationary or travelling fine screens which remove as much of the screenable material as possible before the water enters the raw water reservoir.

The low lift station, then, is a pumping station for the delivery of raw water to the treatment plant, and houses the equipment which provides initial screening for the removal of larger impurities.

MICROSTRAINER– Algae Removal....

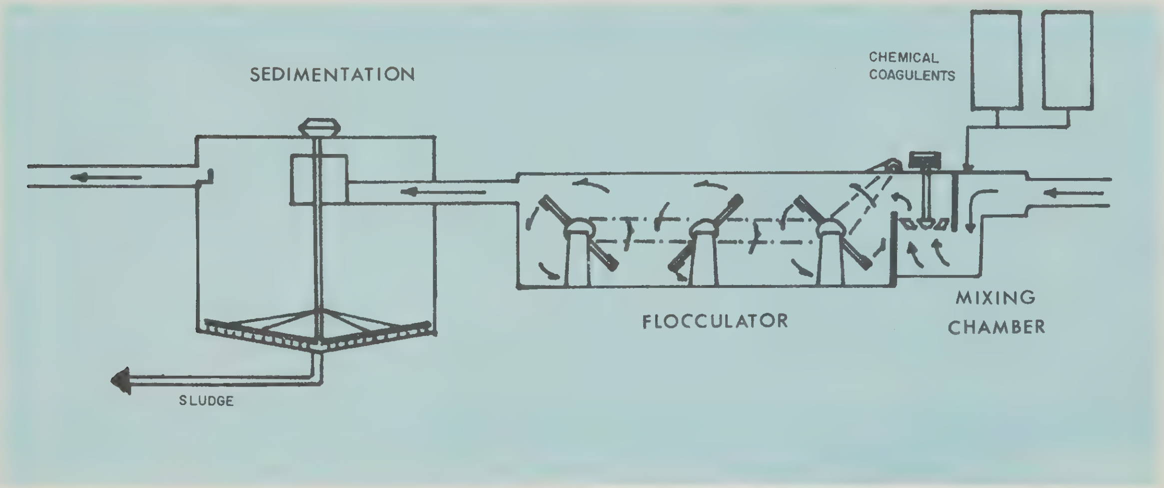
A microstrainer is a rotary drum resting on a concrete frame and is covered with a cloth or steel-mesh blanket. The blanket openings are measured in microns, with the size selected being dependent on the type of algae encountered.



In operation the drum rotates and, as the water passes through, the algae contained in the water are enmeshed on the blanket. Most units are equipped with an ultra-violet light which acts as a germicidal agent on the water. Periodically the microstrainer is backwashed or flushed to remove the accumulated algae and clean the blanket.

FLOCCULATION—Color, Turbidity and Bacteria Removal....

A flocculator is a concrete structure equipped with large paddle-wheels, which rotate to agitate and mix the water passing through. At one end of the flocculator is a small mixing chamber equipped with a revolving blade mixer.



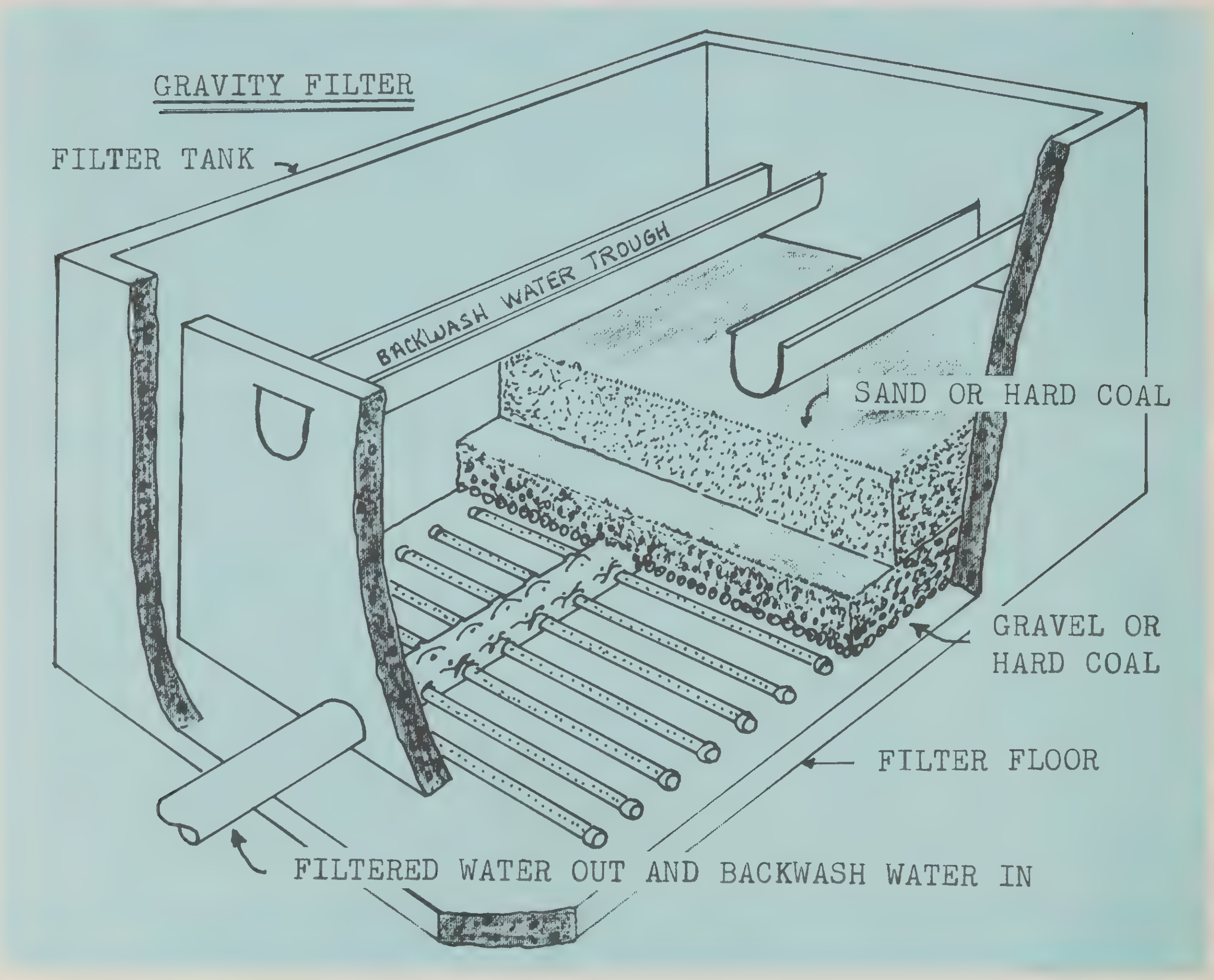
In operation, chemical coagulants such as alum, lime and ferric sulphate are fed into the mixing chamber with the water. These coagulants form a gelatinous, sticky precipitate, which absorbs color and entraps mud, bacteria and suspended matter. The flocculator's agitation allows this gelantinous mass to build up into clumps, or floc, which are readily removed by settling.

A settling basin follows the flocculator where the treated water undergoes a detention period of sufficient time to allow for the settling of the floc. This basin is equipped with facilities for periodic removal of the floc.

FILTRATION – Turbidity and Bacteria Removal....

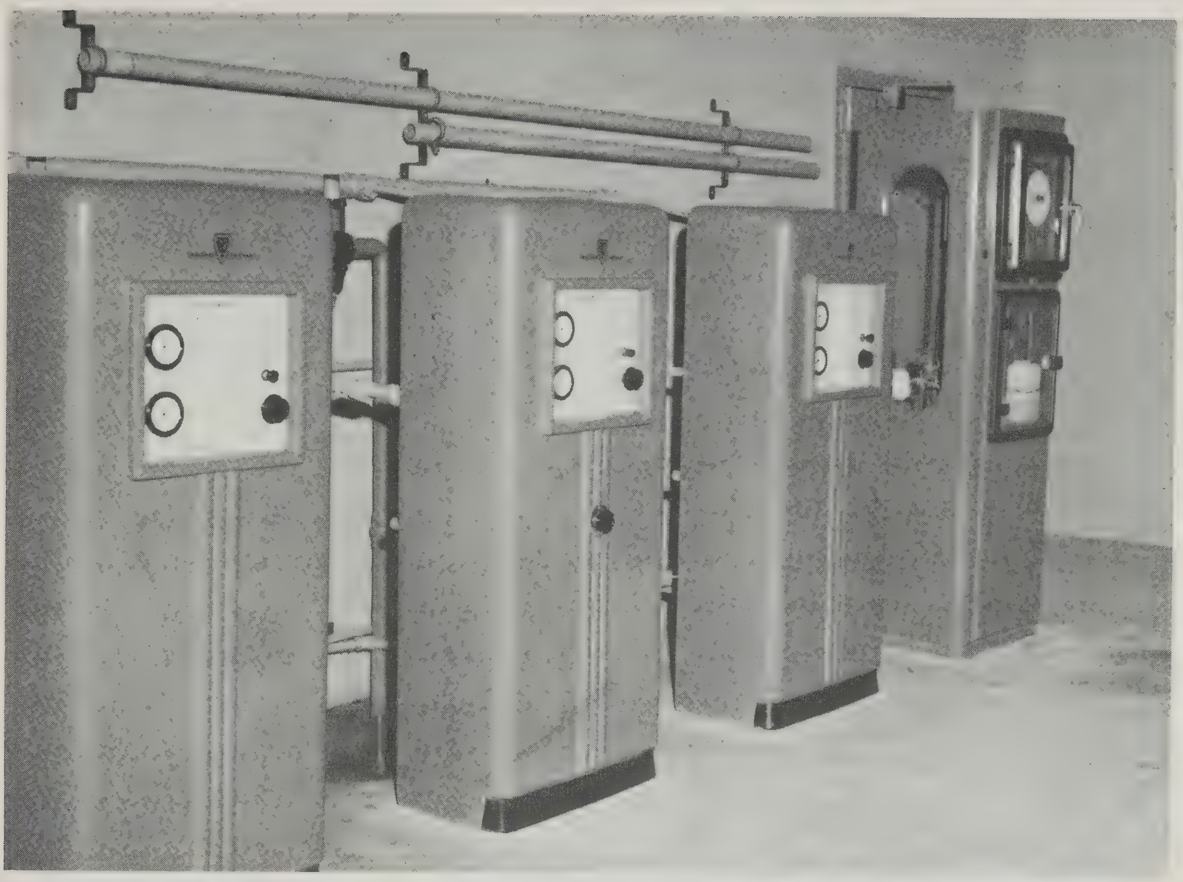
There are two main types of filters used to remove minute impurities from water, the gravity filter and the pressure filter.

The gravity filter is a concrete basin or tank equipped with a straining system and underdrains for the passage of filtered water. The filter media may consist of graded gravel, with a top dressing of graded sand or hard coal carefully crushed to a desired size, or the crushed hard coal alone. The filter also is equipped with backwashing facilities for the periodic cleaning from the media of accumulated impurities.



In operation, the water to be treated flows by gravity through the filter and the impurities contained in the water are transferred to the media. The filtered water then passes through the underdrains into a clear water reservoir.

The pressure filter is a steel tank consisting of the same filter media materials as the gravity filter, except the water is forced through under pressure.



CHLORINATION

The complete removal of pathogenic organisms (disease bacteria) is essential in all water supplies. Water which has been treated adequately should be free of harmful bacteria. To ensure this, chlorine is applied as a germicidal agent before the water is delivered to the consumer.

Chlorine is sometimes used in the early stages of treatment for bacterial reduction. This is referred to as pre-chlorination. Chlorination immediately before delivery to a reservoir or the consumer is referred to as post-chlorination.

FLUORIDATION....

In Ontario, fluoridation of public water supplies has, by an Act of the Provincial Legislature, been made the responsibility of the individual municipalities.

Where a local municipality or a local board owns or operates a water works system, the council of the municipality may, by by-law, establish, maintain and operate a fluoridation system in connection with the water works system.

The council may, before passing such a by-law, submit the question, whether or not to fluoridate the communal water supply, to the electors of the municipality.

* * *

PART 4--Removal of Wastes

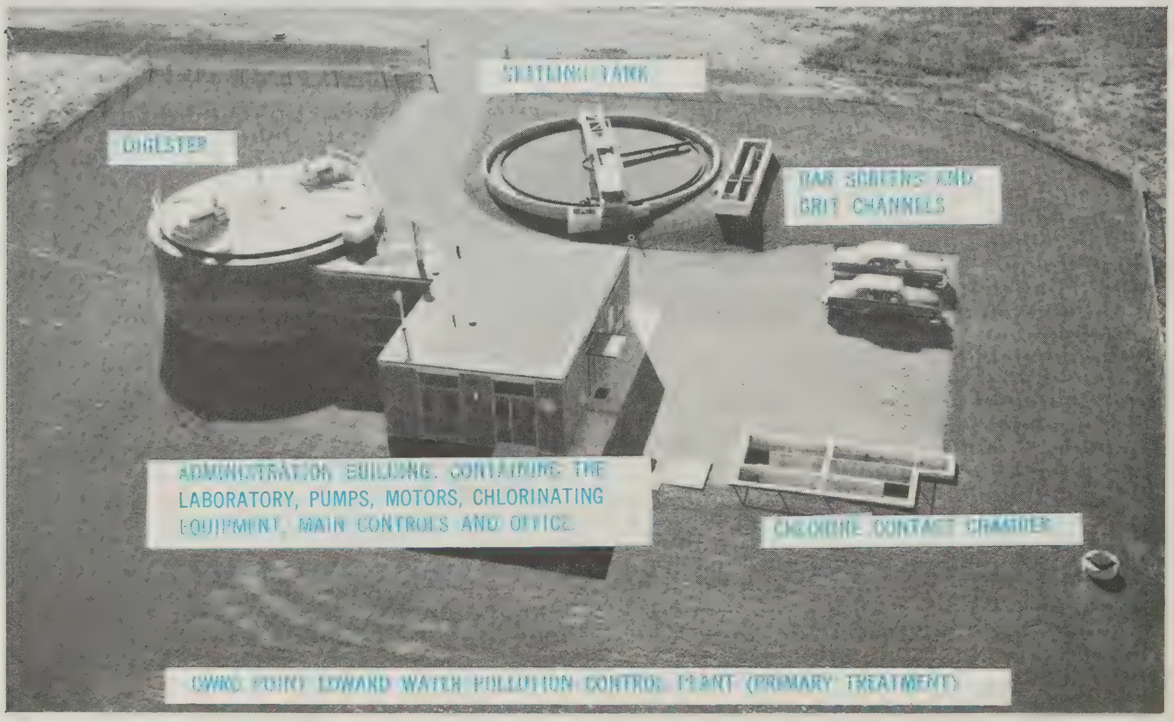
Waste treatment as we know it today is a fairly recent engineering practice. There were sewers centuries ago in India, Rome and a few other places; but they served mainly to collect storm water or, like Rome's famous Cloaca Maxima, to drain marshy areas. In the Middle Ages sewage flowed along open drains which ran through the streets. Later it was carried in conduits to open cesspools located in the outskirts of cities. It was not until the 19th Century that the beginning of modern practices of sewage treatment were put into use.

In the construction of pollution control projects, today, many factors govern the type of process required to achieve the standard of removal necessary to protect the receiving water. The main factors of consideration are the types and volume of the wastes to be treated, the volume and uses of the receiving waters, the population and industrial complex; and the future growth potential of the community.

The best system of sewers is when sanitary sewers (which carry the waste materials) and storm sewers (which carry away rain water from the streets) are separate. In older systems, however, sanitary and storm sewers as a rule were combined and referred to as combined sewers. This method placed an undue hydraulic load on treatment facilities and in many cases required the building of larger facilities than necessary.

The treatment facilities outlined are the major types of treatment utilized by the sanitary engineer to achieve the degree of treatment required. There are many modifications of the biological processes which will achieve the same results, but only the most common types are outlined.

Waste water contains an average of one pound of solids per ton of water and it is the object of treatment to remove as much of these solids as possible.



PRIMARY TREATMENT..

Primary treatment is mechanical in nature, where use is made of settling tanks to remove the settleable solids, floating scum and grease from the waste water.

Settling tanks (clarifiers or sedimentation basins), equipped with sludge and scum removal mechanisms, provide a detention period for the incoming waste water. This detention period allows the waste particles to settle to the bottom of the tanks, from where it is removed by pumps for conditioning prior to disposal.

Primary treatment provides the preliminary treatment required for the biological oxidization of organic materials which is carried out in secondary plants.

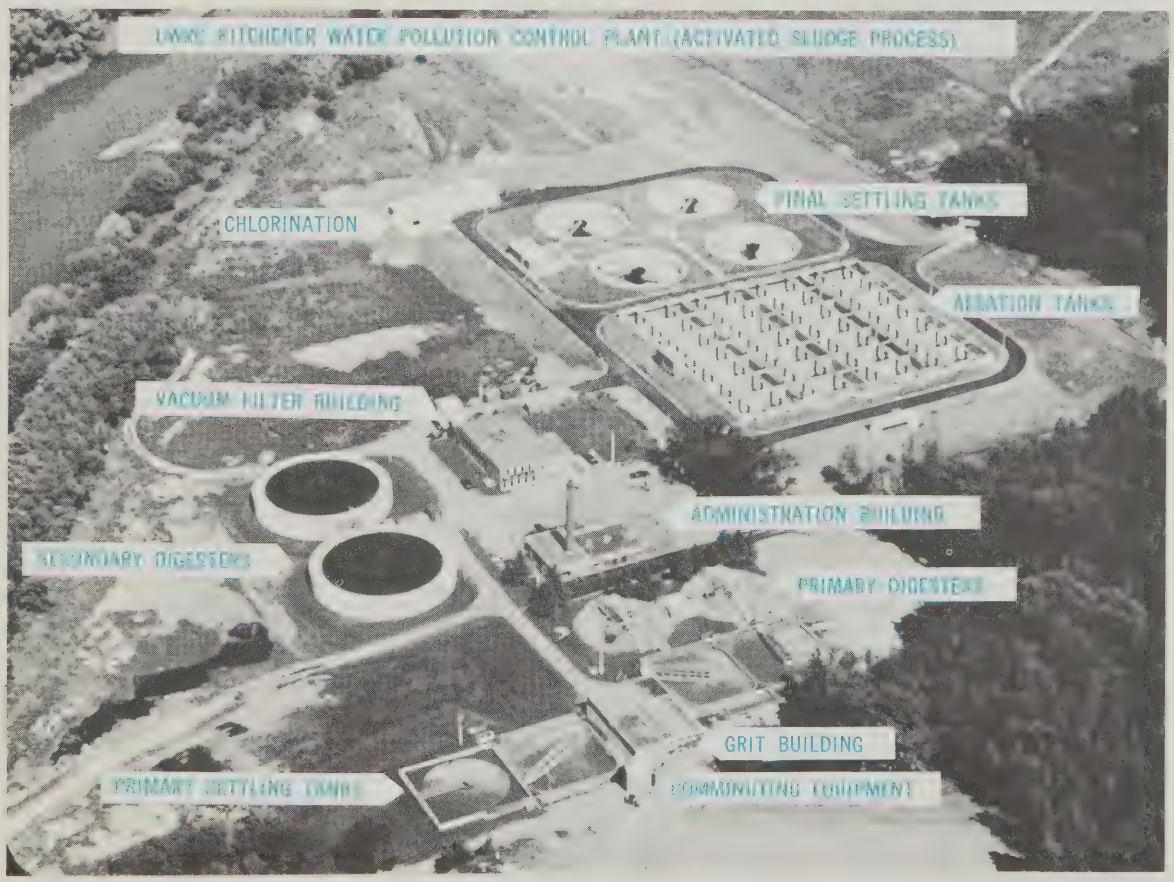
The sludge removed is pumped to a digester or other treatment facility before final disposal.

To summarize: Primary treatment removes the heavier particles, scum and grease from the waste water. The effluent produced is of a lower standard of quality than is achieved in complete treatment. The amount of solids removed ranges from 40 to 60 per cent.

ACTIVATED SLUDGE TREATMENT..

The activated sludge process is a method of complete biological treatment which produces a high quality effluent.

This process is carried out following primary treatment, and takes out the finely divided, suspended and dissolved organic materials remaining in the waste water.



Biological communities of micro-organisms are developed and maintained in an aeration tank where they are supplied with oxygen. The air supply can be provided by compressed air, which is piped directly into the tank, or by means of a mechanical agitator, which revolves and disperses the surface area to allow a greater absorption of atmospheric oxygen by the tank's contents. Besides providing ideal conditions for the micro-organisms, the air, or agitation, also produces a roll in the tank and prevents settling of the solids.

As the organic impurities are assimilated (oxidized) by the micro-organisms, the resulting sludge formation is dense and flocculent, can be settled readily and provides the bacteria with growth environment.

Final settling tanks provide the means for removing and reclaiming this sludge floc. As the effluent from the aeration tanks passes through these settling tanks, the settling sludge floc is removed and returned to the process by means of a pump or pumps and discharged into the aeration tanks again, along with the effluent flowing from the primary settling tanks. This sludge floc is referred to as activated sludge because of the biological communities in it and is the vehicle which maintains the process.

To summarize: Air is supplied to the micro-organisms, which in turn oxidize the finely divided, suspended and dissolved organic materials in the waste water. This provides a high degree of purification and a clear effluent. The amount of solids removed ranges from 90 to 95 per cent.

TOTAL OXIDATION TREATMENT (Modified Activated Sludge)

The total oxidation process is a method of complete biological treatment which produces a high quality effluent.

This process is identical to the activated sludge process in its biological application, but has no primary settling and all the solids contained in the waste water are oxidized through an extended aeration period. The amount of solids removed is about the same as in activated sludge treatment, from 90 to 95 per cent.

TRICKLING FILTER TREATMENT

Standard Rate

The trickling filter process is carried out following primary treatment which removes the heavier settleable solids. This process removes the finely divided, suspended and dissolved materials remaining in the waste water.

The filter is constructed of a bed of crushed rock which provides a large surface area for the development and growth of colonies of micro-organisms.

Aerobic nitrifying bacteria build up on the crushed rock and, as the waste water is fed through, the organisms oxidize the organic materials contained in the water. The oxygen required by the organisms is supplied from the atmosphere, passing down through the bed.

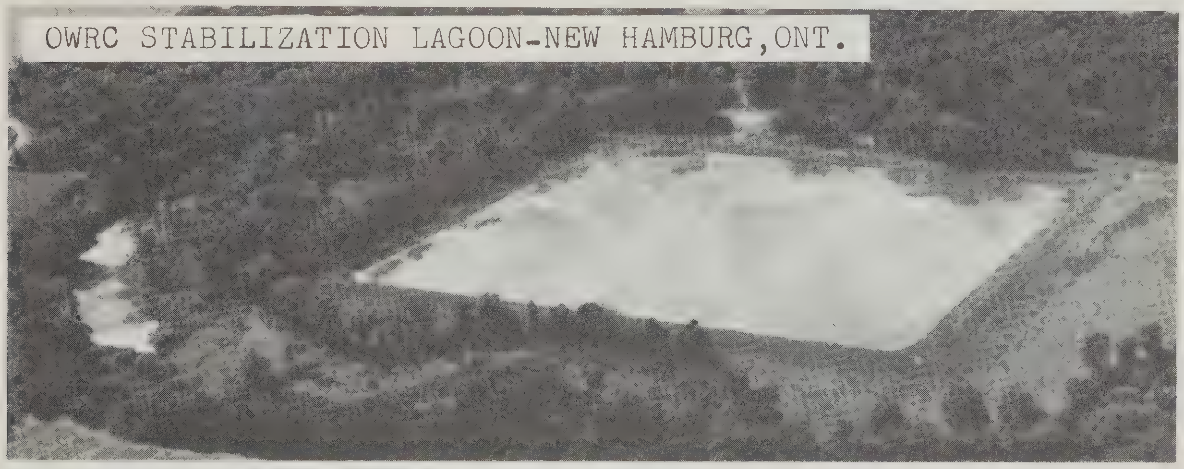
The waste water is discharged onto the crushed rock through perforated rotating arms which place an even flow over the entire surface area.

The underdrain system is a specially constructed tile which supports the stone and carries off the effluent. As the filter builds up with the oxidized material, it periodically falls away from the filter media and settles out in a subsequent unit.

High Rate

Recirculation of the material settling in the final tank provides additional biological treatment and is especially useful in treating certain types of industrial wastes. The methods and points of recirculation vary with design and equipment, but the filter is constructed the same as the standard rate filter.

To summarize: The aerobic micro-organisms, supplied with oxygen, oxidize the organic matter and produce rapid settling. This form of treatment produces a high degree of purification. The amount of solids removed ranges from 90 to 95 per cent.



OWRC STABILIZATION LAGOON-NEW HAMBURG,ONT.

TREATMENT IN WASTE STABILIZATION LAGOONS

A waste stabilization lagoon makes use of natural purification processes which are partially regulated. In nature, micro-organisms react with organic material and break it down into carbon dioxide and micobial cell material which is nuisance free. Natural purification is achieved by microbes present in soil, by oxygen, by organic material (food for microbes) and dissolved materials working together.

In a lagoon, loading, depth, soil conditions and liquid losses, all of which are controlled, together with wind action, sunlight, algae growth and oxygen are contributing factors in providing the environment necessary for the development of the aerobic bacterial action and photo-synthetic oxidation required to stabilize the wastes.

The micro-organisms cultivated convert much of the organic carbon in the wastes to carbon dioxide. This carbon dioxide, together with dissolved minerals and sunlight, provide conditions for the growth of algae, which in turn provides a plentiful supply of oxygen for the micro-organisms. When the organic materials have been converted into bacterial bodies, dissolved minerals and gasses, the stable liquid portion remaining is discharged to a receiving body or evaporates into the atmosphere.

To summarize: the waste water is collected in a lagoon where, by partially regulating the natural purification process, the organic materials are converted and the waste water purified. This is accomplished in such a manner that no nuisance conditions develop.

OWRC STABILIZATION LAGOON — PLAYFAIR TWP., ONT.

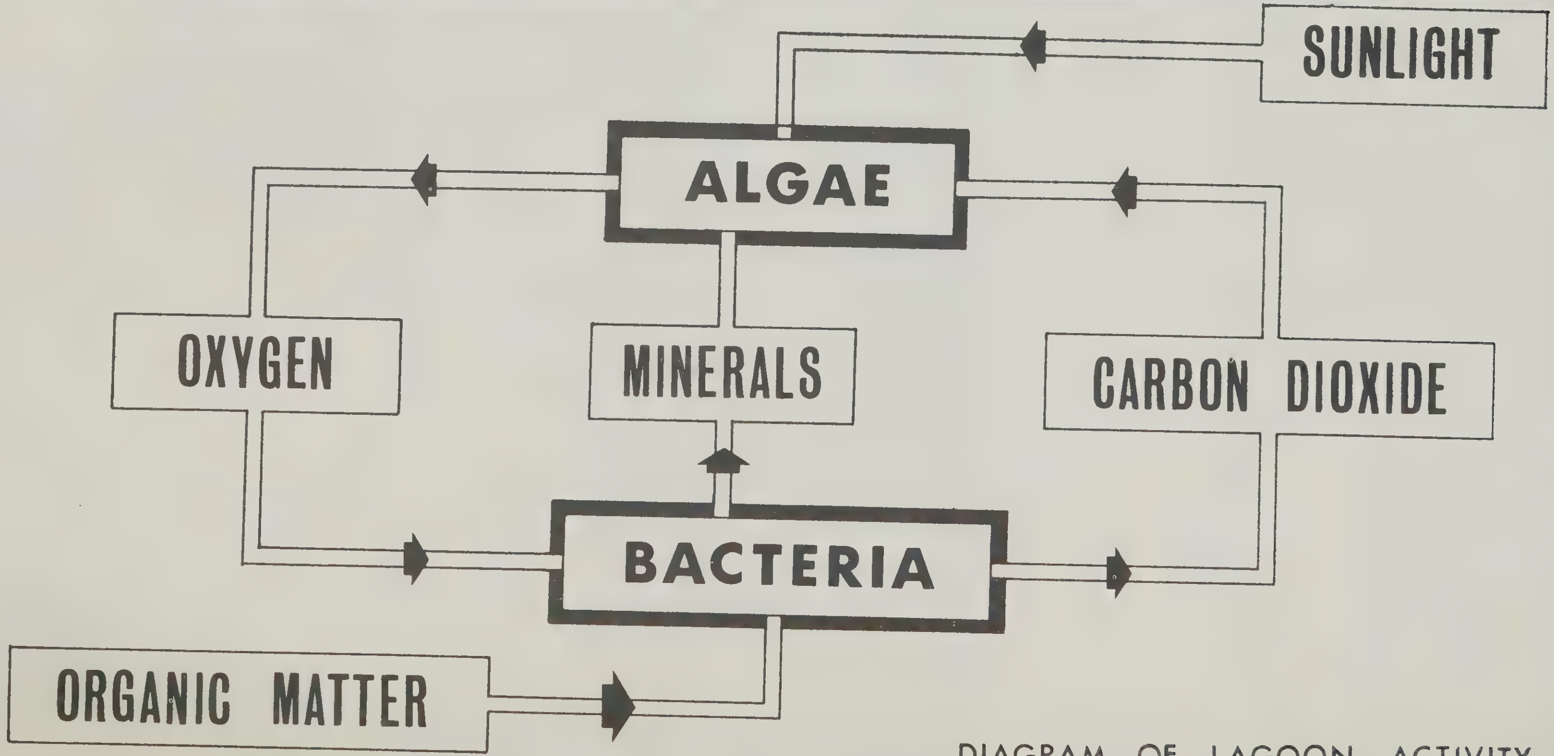


DIAGRAM OF LAGOON ACTIVITY

TREATMENT OF SLUDGE

Digestion

Digestion is the decomposition of the solids settled in primary clarifiers and waste activated sludge by anaerobic bacteria. This is carried out in a digester, which is a specially constructed tank.

The raw sludge is pumped to the digester where it is broken down by anaerobic bacterial action, at a regulated temperature of from 90 to 95 degrees Fahrenheit. When it is thoroughly digested, it is a thick, black, odorless liquid which can be used as a soil conditioner.

A product of digestion is methane gas which is utilized as fuel for heat exchangers and boilers.

In smaller plants the entire process is usually carried out in one digester, but in larger plants usually two digesters are required to handle the larger volume of sludge and the process is carried out in two stages.

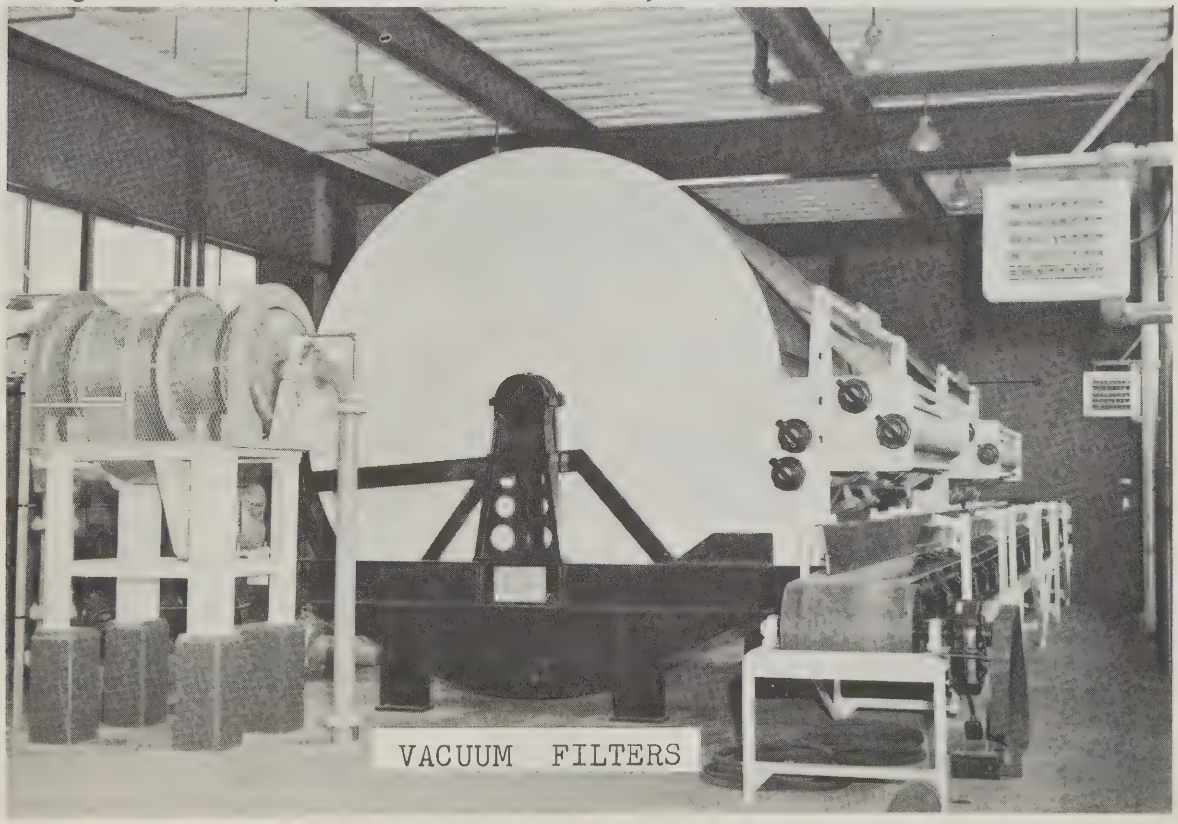
Vacuum Filtration

Where large volumes of sludge must be handled, vacuum filters are utilized to reduce the volume by dewatering.

The filter consists of a porous drum around which is wrapped a cloth or steel-coil blanket. The drum blanket picks up the sludge, thickened with the aid of chemical coagulants, from a trough. As the drum and blanket rotate, water is removed from the sludge by a partial vacuum exerted from inside the drum. A scraper edge removes the dewatered sludge cake and it drops onto a conveyor for delivery to a disposal area.

Sludge Area

In smaller installations sludge drying beds provide the means for dewatering the sludge. The beds, which are equipped with underdrains, are covered with sludge which is dried through moisture evaporation and the underdrain system.



VACUUM FILTERS

ADDITIONAL DESIGN FEATURES

Coarse Bar Screens: A coarse bar screen is a protective screen installed at the influent or entrance to the plant or pumping station to prevent the entry of large objects which could damage machinery or equipment.

Comminution: Comminuting (shredding) equipment is used to reduce large particles in the flow to a size suitable for handling in the treatment units. These units are installed ahead of, or behind, grit and sand removal facilities.

Grit and Sand Removal: Through the use of channels or chambers, the velocity of flow of the incoming waste water is reduced sufficiently to allow grit and sand, which is heavier than the organic matter, to settle out for removal. When channels are utilized, the normal flow of the waste water keeps the organic material in suspension. When chambers are utilized, organic return pumps are sometimes installed to assist in this function. Aerated grit chambers provide another means of removal. As the grit and sand settle, a suction pipe draws the contents from the bottom of the chamber and deposits it into channels or a hopper, from where the water is returned to the flow and the grit and sand collects for periodic removal. The turbulence of the water in the chamber keeps the organic material in suspension.

Effluent Filter: Where required, a sand filter is installed to filter the effluent before it is discharged to a watercourse. When receiving waters are small or very low flows are encountered during the summer months, this method of "polishing" the effluent is very effective and ensures a high degree of removal for any remaining waste materials from the final effluent before discharge.

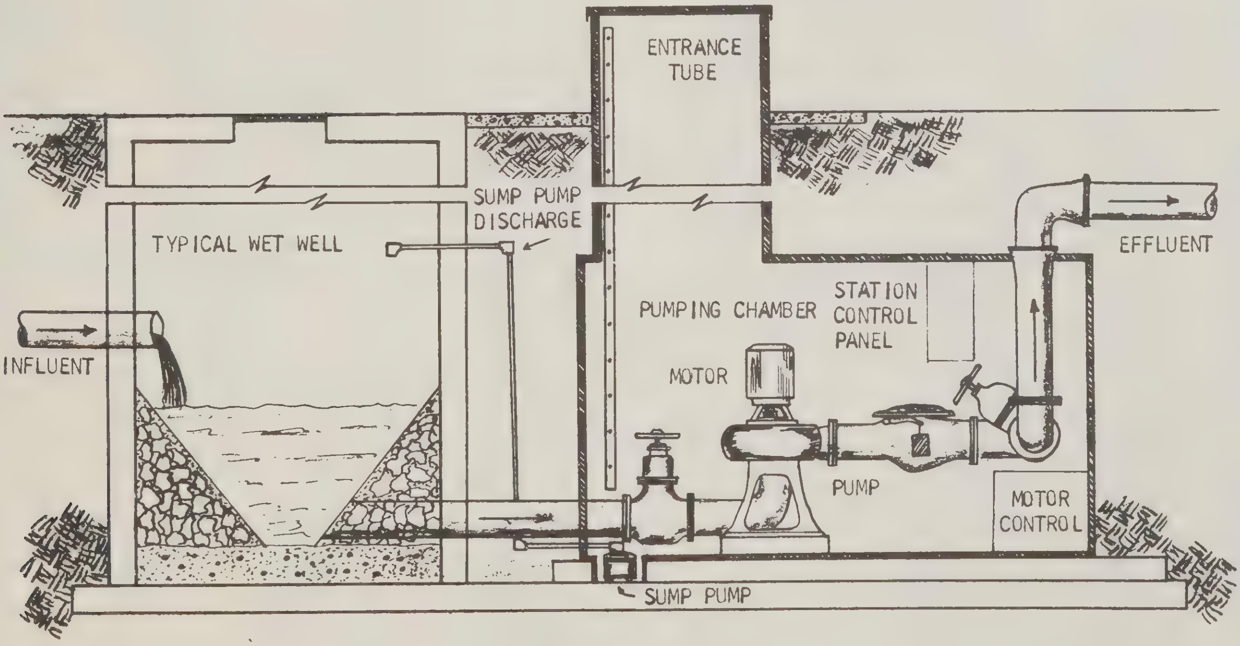
Chlorination: Chlorinating facilities are provided to disinfect the effluent before discharge from a plant. In most cases a chlorine contact chamber is utilized for this purpose. In this chamber the final effluent undergoes a detention period of from 15 to 30 minutes to ensure a good contact with the chlorine. The effluent outfall sewer, running from the plant to the receiving waters, is sometimes utilized as a means of chlorinating the effluent. The function is essentially the same as for the chamber.

Underground Pumping Stations:

In many communities underground pumping stations are utilized to raise the level or elevation of flow in low lying areas of a community, or for collecting the waste water at terminal points in the sewer system and discharging it to a lagoon or sewage treatment plant.

An underground station consists of a wet well, where the waste water is collected for periodic removal, and an equipment chamber (dry well), which contains the control equipment, pumps, motors and other units necessary to its operation.

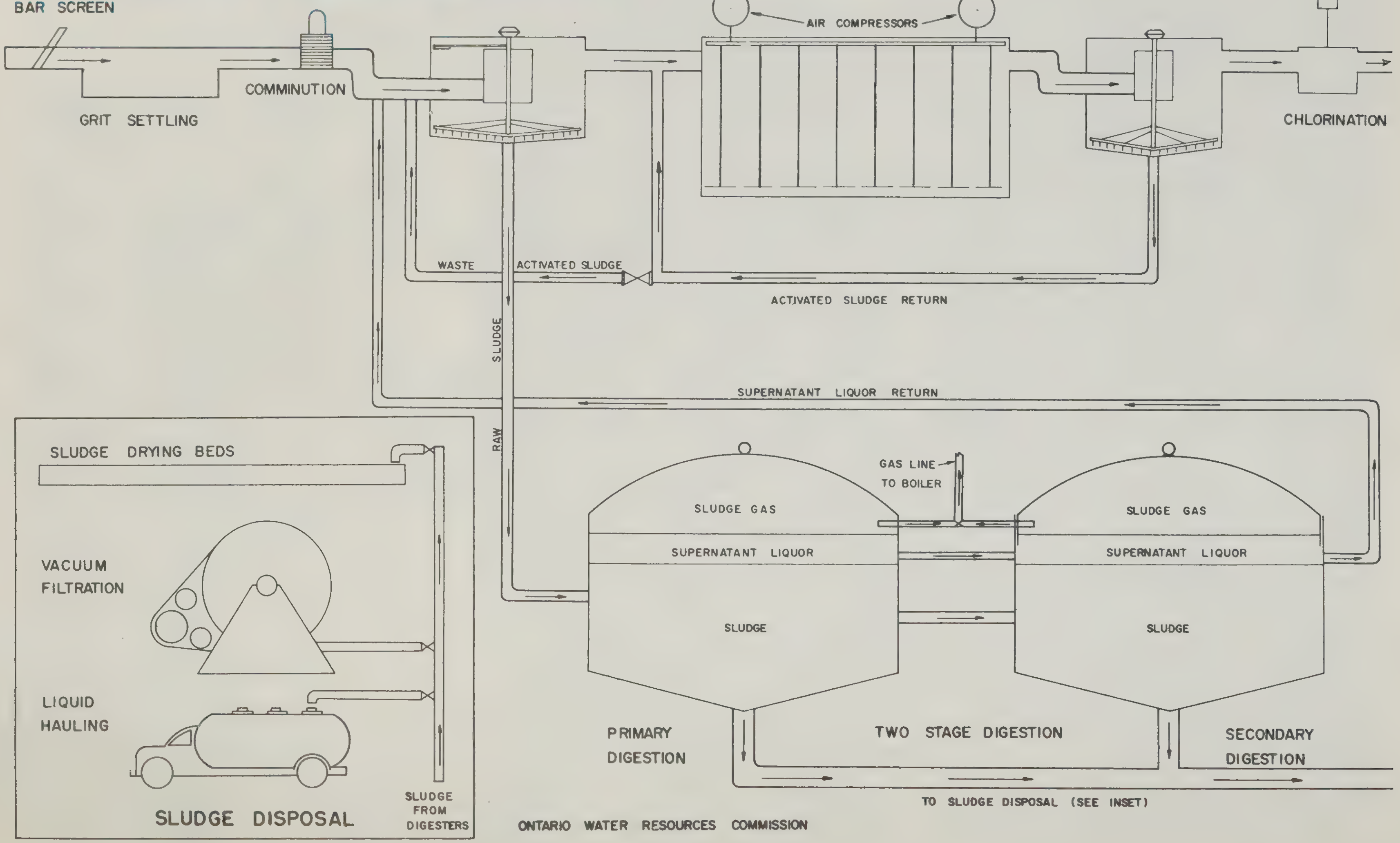
These units are automatically operated by the level of the water in the wet well. Pictured below is a typical underground pumping station.



TYPICAL UNDERGROUND PUMPING STATION

WATER POLLUTION CONTROL PLANT FLOW DIAGRAM

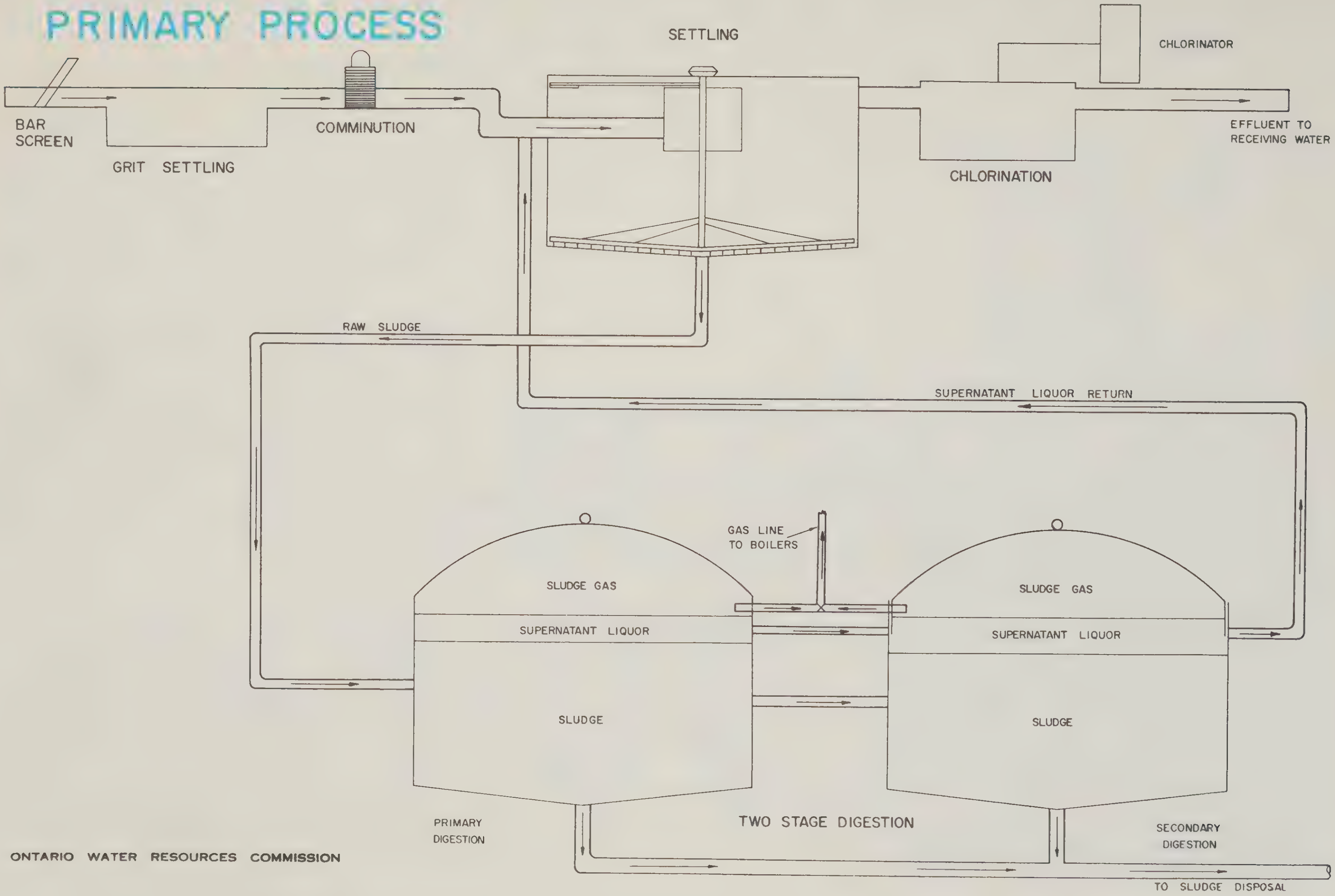
ACTIVATED SLUDGE PROCESS



ONTARIO WATER RESOURCES COMMISSION

WATER POLLUTION CONTROL PLANT FLOW DIAGRAM

PRIMARY PROCESS

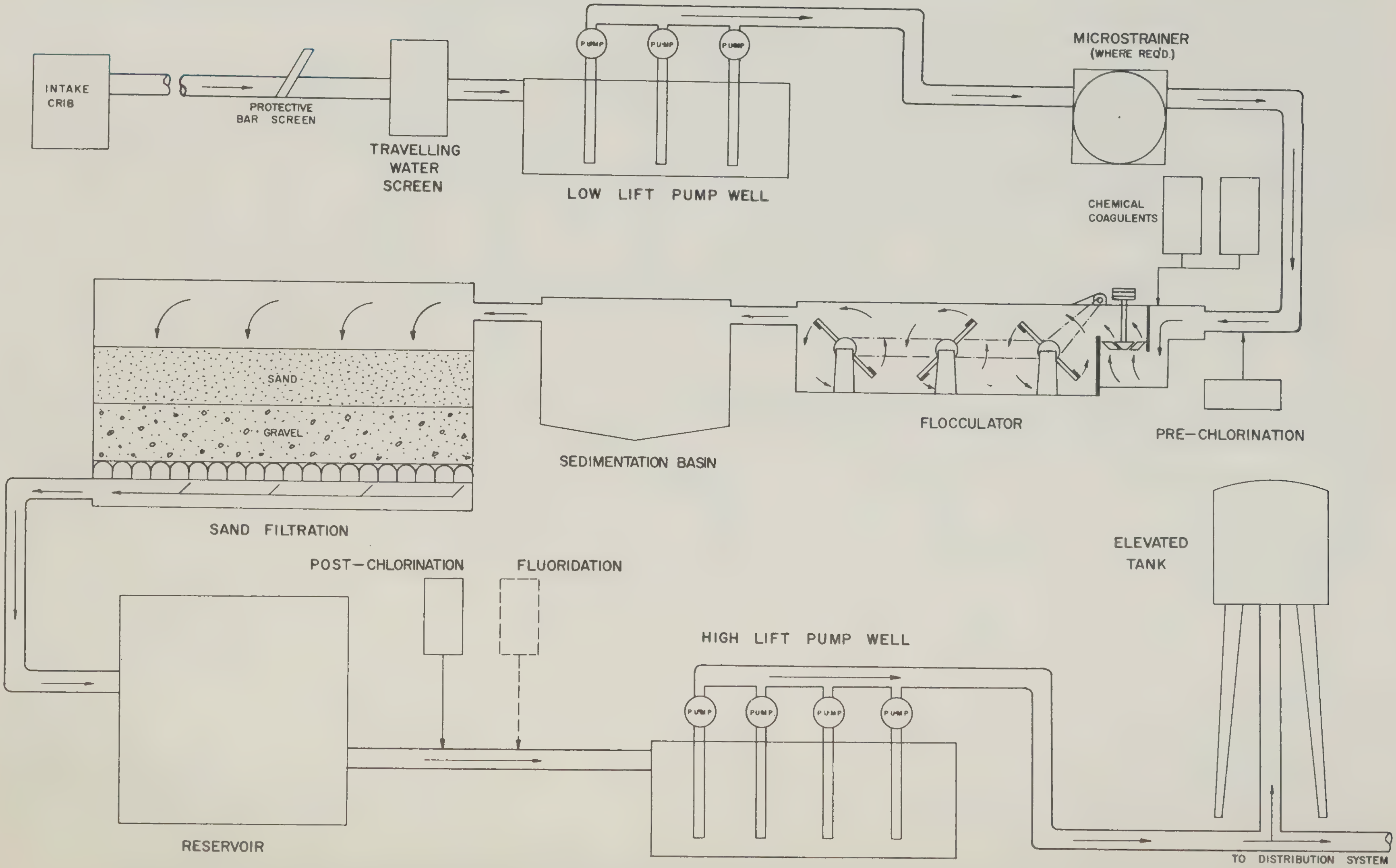


ONTARIO WATER RESOURCES COMMISSION

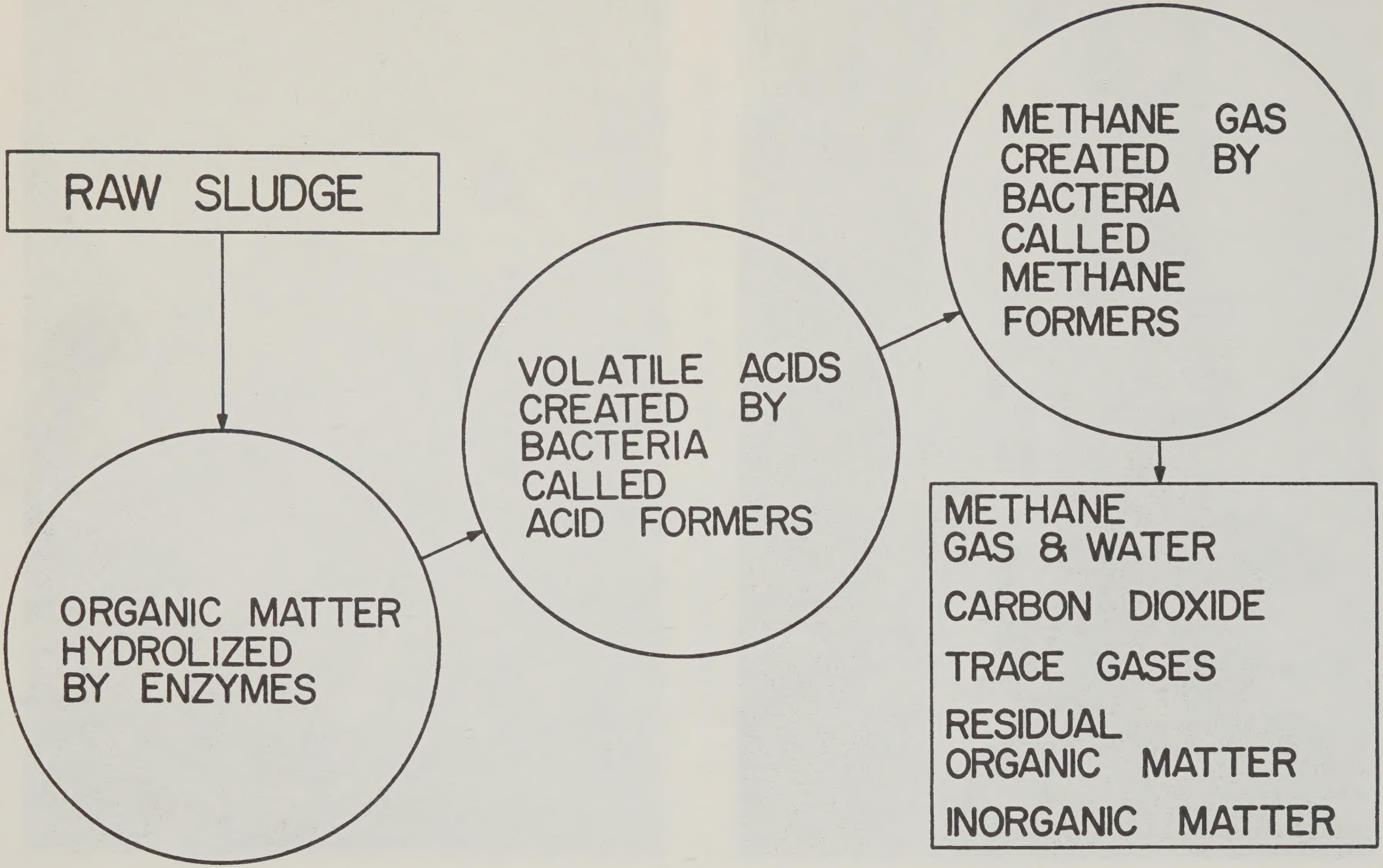
WATER TREATMENT PLANT FLOW DIAGRAM

ONTARIO WATER RESOURCES COMMISSION

SURFACE WATER SUPPLY



BASIC ANAEROBIC ALKALINE DIGESTION PROCESS



CLEAN OR POLLUTED — EVERYONE HAS A RESPONSIBILITY